

इंटरनेट

मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

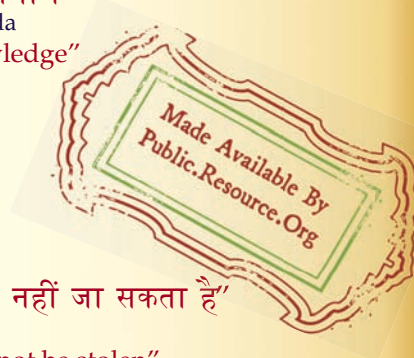
IS 15204 (2002): Microwave Ferrite Components - Measuring Methods for Major Properties [LITD 5: Semiconductor and Other Electronic Components and Devices]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE



भारतीय मानक
माइक्रोवेव फेराइट घटक — मुख्य गुणधर्मों के लिए
मापन पद्धतियाँ

Indian Standard

**MICROWAVE FERRITE COMPONENTS —
MEASURING METHODS FOR MAJOR PROPERTIES**

ICS 29.030; 29.100.10

© BIS 2002

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

NATIONAL FOREWORD

This Indian Standard which is identical with IEC 61830 (1997) 'Microwave ferrite components — Measuring methods for major properties' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of Magnetic Components and Ferrite Materials Sectional Committee and approval of the Electronics and Telecommunication Division Council.

This standard provides guidance on the methods of measurement for the properties of microwave ferrite components.

The text of the IEC Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

CROSS REFERENCE

The concerned Technical Committee responsible for preparation of this standard has reviewed the provisions of the following International Publication and has decided that it is acceptable for use in conjunction with this standard:

IEC 60510-1-3 (1980)	Methods of measurement for radio equipment used in satellite earth stations — Part 1 : Measurements common to sub-systems and combinations of sub-systems — Section 3 : Measurements in the i.f. range [Amendment 1 (1988)]
------------------------	---

Only the English language text of the International Standard has been retained while adopting it in this Indian Standard.

Indian Standard

MICROWAVE FERRITE COMPONENTS — MEASURING METHODS FOR MAJOR PROPERTIES

1 Scope

This International Standard gives guidance on the measuring methods for major microwave properties, such as return loss, forward loss, reverse loss, phase shift and group delay, of microwave ferrite components.

NOTE 1 – The methods of measurement are compiled after the model of IEC 60510-1-3.

NOTE 2 – Network analyzers are being used by most manufacturers to evaluate such properties of microwave ferrite components at present. However, knowledge of basic measuring methods is necessary for understanding the general purpose of measurements including the use of network analyzers. Therefore, orthodox methods of measurement are described herein.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60510-1-3: 1980, *Methods of measurement for radio equipment used in satellite earth stations – Part 1: Measurements common to sub-systems and combinations of sub-systems – Section three: Measurements in the i.f. range*
Amendment 1 (1988)

3 Return loss

3.1 The relationship between impedance, return loss, reflection coefficient and voltage standing wave ratio (VSWR)

In microwave ferrite components, interest is essentially in the measurement of return loss rather than that of impedance, reflection coefficient, or VSWR.

The return loss L in decibels of an impedance Z relative to its nominal value Z_0 is given by:

$$L = 20 \log_{10} \left| \frac{Z + Z_0}{Z - Z_0} \right| \quad (1)$$

Alternatively, the return loss in decibels is given by:

$$L = 20 \log_{10} \left| \frac{1}{\rho} \right| \quad (2)$$

where ρ is the voltage reflection coefficient of the impedance Z relative to Z_0 , i.e.

$$\rho = \frac{Z - Z_0}{Z + Z_0} \quad (3)$$

VSWR is given by:

$$VSWR = \frac{1 + |\rho|}{1 - |\rho|} \quad (4)$$

3.2 Method of measurement of return loss

Measurements may be made by using either point-by-point or sweep-frequency methods. For the latter case, an example is described in following subclauses, but any alternative method capable of providing the required accuracy (typically ± 1 dB) may be used. In this example, the equipments listed below and shown in figure 1, are needed:

- a sweep-frequency generator;
- a microwave bridge;
- a calibrated attenuator;
- an amplitude detector;
- an oscilloscope.

The method is intended for measuring the return loss of linear and passive ports, for example the input impedance of an isolator. It also may be used for measuring the return loss of linear, active and passive devices, for example at the output of device (source impedance) provided that no signal is present and that the device under test can be considered as a linear, passive network.

The return loss of cables, attenuators, adapters, etc., used during the measurements, as well as the return loss at the input and the output of measuring equipment, may be checked using the same method.

3.3 General considerations of the measuring equipment

3.3.1 Sweep-frequency generator

Over a specified frequency range, the generator should be able to generate a sinusoidal, radio frequency signal, and its output level should be constant.

The repetition rate f_s of the sweep should be in the range 10 Hz to 100 Hz provided that the passband of the receiver section, i.e., amplitude detector and oscilloscope, is about 50 times to 100 times the chosen sweep rate.

3.3.2 Microwave bridge

Over a specified range of signal levels, the voltage at the output of the bridge should be proportional to the magnitude of the reflection coefficient of the impedance under test.

3.3.3 Detector sensitivity

The minimum level detectable by the detector should be at least 20 dB below the minimum level expected from the bridge under conditions given in 3.4.3.

3.4 Measuring procedure

3.4.1 General

The measuring procedure comprises three steps: namely, calibration, balance check of the bridge and measurement.

3.4.2 Calibration

The output level of the sweep-frequency generator is adjusted to obtain the desired voltage across the impedance Z in the bridge. Care should be taken to avoid overloading the equipment under test.

The test arm of the bridge is left short-circuited and the calibrated attenuator is then adjusted to obtain a suitable d.c. level at the output of the amplitude detector.

3.4.3 Checking the residual return loss of the bridge

A matched load Z_0 , coaxial or waveguide, is connected to the bridge in place of the unknown impedance Z .

The residual return loss is then checked by adjusting the calibrated attenuator until the traces on the screen of the oscilloscope approach coincidence. It is possible to obtain exact coincidence only if sufficient receiver sensitivity is available.

The setting of the attenuator should be noted when coincidence of the traces occurs or when the limit of receiver sensitivity is reached. This setting determines the maximum value of return loss which can be measured with specified accuracy. Return loss values up to 20 dB less than the value obtained above can be measured with an accuracy of ± 1 dB. For example, when the value is 50 dB, return loss values up to 30 dB can be measured with an accuracy of ± 1 dB.

3.4.4 Measurement of return loss

One port of the device under test with unknown impedance Z is connected to the bridge and the other port(s) of the device should be terminated by matched load(s) Z_0 . The calibrated attenuator is adjusted until the measuring trace and the reference trace on the screen of the oscilloscope coincide at the specified frequency as indicated by the frequency marker.

The difference between this attenuator setting and that obtained under 3.4.2 is equal to the return loss of the unknown impedance Z .

When it is necessary to measure return loss of the other ports of the device, repeat the above procedure regarding the port to be measured.

3.5 Presentation of results

The results of the measurements should be presented preferably as a curve or photograph of the oscilloscope display with the vertical scale as shown in figure 2 or with this scale inverted. Reference lines may be added on the oscilloscope display.

In every case the residual return loss curve should be shown as well as the measured curve.

When the results of the measurements are not presented graphically, they should be given as in the following example:

- a) return loss more than 23 dB from 3,5 GHz to 4,5 GHz;
- b) residual return loss more than 45 dB.

3.6 Detail to be specified

The following should be included as required in the detailed equipment specification:

- a) return loss limits;
- b) frequency band limits.

4 Forward loss and reverse loss

4.1 Definition and general considerations

The forward loss and reverse loss are given by the curve representing the difference, expressed in decibels, between the output level and a reference level, as a function of frequency for a constant input level.

4.2 Method of measurement

Measurements may be made using either point-by-point or sweep-frequency methods. For the latter case, an example of the arrangement of the measuring equipment is shown in figure 3. Use of isolators at the input and output port of the device under test is recommended to reduce mismatch errors.

4.3 General considerations of the measuring equipment

When using the sweep-frequency methods, repetition of the sweep-frequency generator, the waveform of the sweep signal and the pass-band of the detector and the oscilloscope should conform to 3.3.1.

Care should be taken to ensure that the results of the measurements are not affected by harmonics of the test signal.

Before commencing the measurements on the equipment to be tested, the magnitude of the inherent errors of the measuring equipment including the cables, attenuators and other accessories which are to be used, should be calibrated by connecting the output of the signal generator to the input of the detector.

When measurements are made on the devices having no connectors such as stripline or pin type devices, appropriate test fixture furnished with connectors should be used.

Mismatch error limits E in decibels are given by:

$$E = 20 \log_{10} (1 - |\rho_1 \rho_2|) \quad (5)$$

where

ρ_1 is the voltage reflection coefficient of the output port of the device under test;

ρ_2 is the voltage reflection coefficient of the detector including isolator.

For example, when $\rho_1\rho_2$ is less than 0,0023, in other words the sum of return losses of the device under test and the detector including isolator is larger than 53 dB, forward loss can be measured to within $\pm 0,02$ dB.

4.4 Measuring procedure

4.4.1 General

The measuring procedure comprises two steps: calibration and measurement.

4.4.2 Calibration

The output level from the signal generator is connected to the detector including isolator to calibrate the inherent errors of the measuring equipment and to establish reference output level. The calibrated attenuator should be set at an adequate attenuation to achieve measurement.

When it is necessary to exclude the loss of the test fixture, calibration should be made including the loss of the test fixture.

Such a calibration can be made by using a test fixture having a straight line of Z_0 connected between input port and output port of the test fixture.

4.4.3 Measurement of forward loss and reverse loss

The device under test is connected between the signal generator and the detector. Then the calibrated attenuator is adjusted until the measuring trace and the reference trace on the screen of the oscilloscope coincide at the specified frequency indicated by the frequency marker.

The difference between this attenuator setting and that obtained under 4.4.2 is equal to the forward loss or reverse loss of the device under test.

In the case of the circulators which have three or more ports, the port(s) except the input port and output port should be terminated by matched load(s) and the above measurement should be repeated changing the ports to be measured as described in 3.4.4.

4.5 Presentation of results

4.5.1 Forward loss and reverse loss

The results of the measurements should be presented, preferably, as a curve or photograph of the oscilloscope display as shown in figure 4. Both the horizontal and the vertical scales of the oscilloscope display should be calibrated.

When the results of the measurements are not presented graphically, they should be given as in the following example:

- a) forward loss (port 1 to port 2) less than 0,2 dB from 3,5 GHz to 4,5 GHz;
- b) reverse loss (port 2 to port 1) larger than 23 dB from 3,5 GHz to 4,5 GHz.

4.5.2 Ripple components

When ripple components are easily identifiable from the measured characteristic, they should be expressed in decibels, peak-to-peak. The ripple frequencies should be stated.

5 Phase-shift and group-delay

5.1 Definition and general considerations

For a linear network, the transfer function $H(j\omega)$ is written as:

$$H(j\omega) = A(\omega) e^{-jB(\omega)} \quad (6)$$

Where $A(\omega)$ is related to its amplitude/frequency characteristic and $B(\omega)$ is related to its phase/frequency characteristic (considered positive if the output signal lags the input signal).

The phase-shift $\phi(\omega)$ in radians is defined as follows:

$$\phi(\omega) = B(\omega) - 2\pi n \quad (7)$$

where n is an integer.

It is usual to measure the phase variation, which is the difference between the measured phase and the reference phase as a function of frequency. The group-delay $\tau(\omega)$ of the network is defined as the first derivative of $B(\omega)$, with respect to ω , namely:

$$\tau(\omega) = \frac{d B(\omega)}{d \omega} \quad (8)$$

and is expressed in seconds.

It is usual to measure group-delay variation, which is the difference between the group-delay as stated above and the group-delay at a reference frequency.

5.2 Method of measurement

Measurements may be made using either point-by-point or sweep-frequency methods. For the latter case, an example of the arrangement of the measuring equipment is shown in figure 5.

5.2.1 General considerations of the measuring equipment

The following conditions should apply:

- a) the modulation index and modulating frequency f_m should be chosen to ensure that the corresponding spectrum occupies a bandwidth within which the amplitude/frequency and group-delay characteristics of the device under test can be approximated by a straight line;
- b) synchronous amplitude modulation generated by the modulator should be negligible in relation to the amplitude to phase conversion effects, and to the transmission capacity of the device under test. The demodulator should be insensitive to synchronous amplitude modulation, and demodulators of the frequency-following type are well suited to this purpose;
- c) the phase detector should be insensitive to amplitude modulation which is synchronous with the sweep frequency;
- d) the modulator and the demodulator shown in figure 5 should be of the highest quality. In particular, they should be designed for a constant group-delay response.

When the above conditions are fulfilled, the output voltage V from the phase detector (see figure 5) is related to the group-delay $\tau(\omega)$ of the device under test as follows:

$$V = k \mu \tau(\omega) \quad (9)$$

where k is a constant representing the phase-detector slope in V/rad and $\mu = 2\pi f_m$.

NOTE – The phase detector (see figure 5) may be used to measure the phase difference ($\mu\tau$) in addition to group-delay variation τ . If a modulating frequency of 0,277 778 MHz is used, the output voltage from the detector for a 1° phase difference will be the same as that for a group-delay variation of 10 ns. Other test frequencies satisfying condition of item a) above are acceptable for f_m , but not very low values (e.g. 10 kHz), in order to avoid the effects of excessive noise.

5.2.2 Measuring procedure

In the preferred method shown in figure 5, a radio frequency (r.f.) signal having a frequency f and a modulation test signal having a frequency f_m are fed to a high-quality modulator which generates a frequency-modulated r.f. signal at a low modulation index by the modulation test signal.

The modulated r.f. signal is fed to the device under test and is then demodulated by a high-quality demodulator which recovers the modulation test signal f_m .

As the r.f. signal is swept over the specified bandwidth, the demodulated modulation test signal undergoes amplitude and phase variations. The signal from the phase detector is proportional to the r.f. phase-shift and group-delay.

5.3 Presentation of results

5.3.1 Phase-shift and group-delay characteristics

The phase-shift and/or group-delay characteristic should be presented preferably as a reproduction of the oscilloscope display with frequency on the abscissa, as shown in figure 6.

When the results are not presented graphically, they should be given as in the following example:

- a) phase-shift is 90° at 4 GHz and phase-shift variation is $\pm 5^\circ$ in the frequency band 3,5 GHz to 4,5 GHz;
- b) total group-delay variation is 2,5 ns in the frequency band 3,5 GHz to 4,5 GHz.

The modulating frequency f_m and the corresponding modulation index should be given.

5.3.2 Ripple components

When ripple components are identifiable from the measured characteristic, their amplitude should be expressed in degrees and/or nanoseconds, peak-to-peak. The ripple frequencies should be stated.

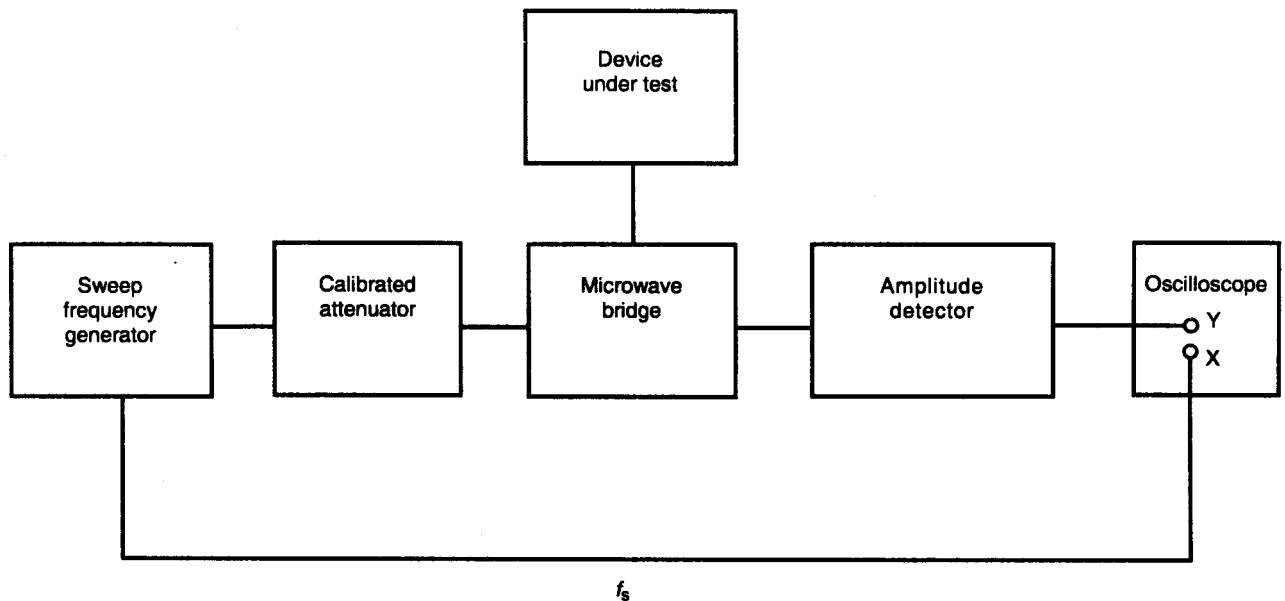


Figure 1 – Arrangement of equipment for measuring return loss

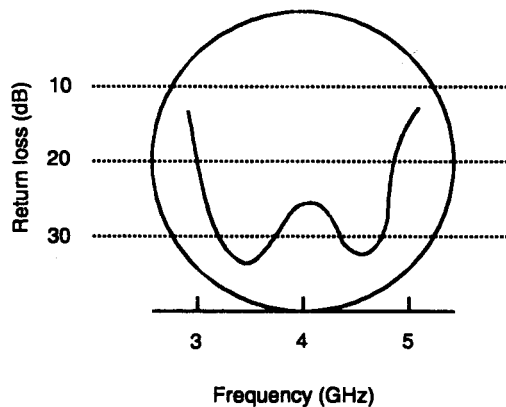


Figure 2 – Example of oscilloscope display of return loss

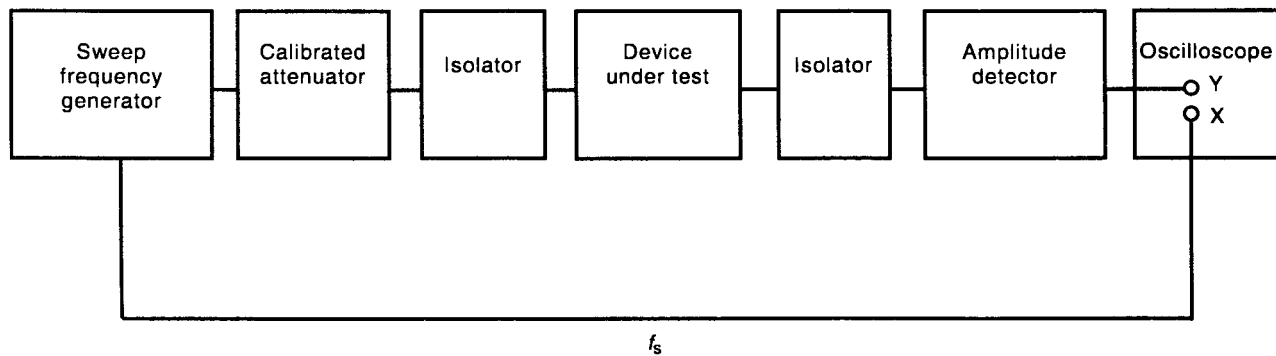


Figure 3 – Arrangement of equipment for measuring forward loss and reverse loss

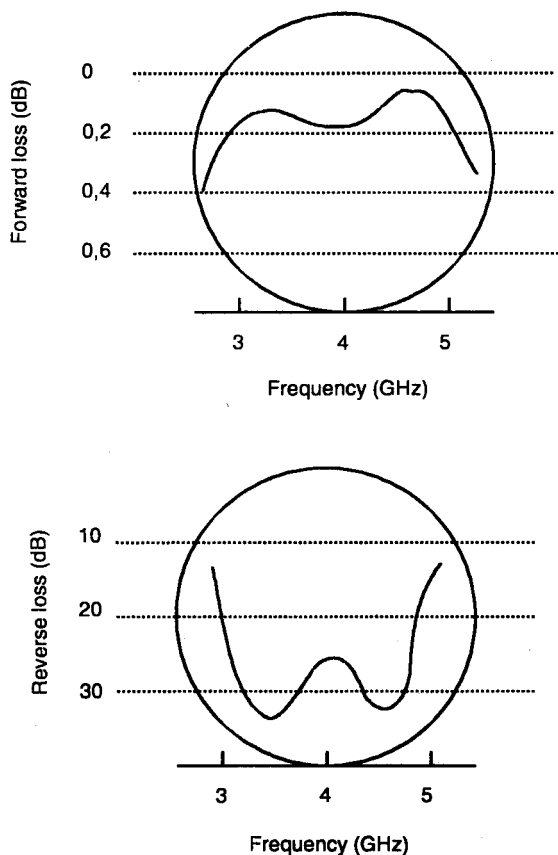


Figure 4 – Example of oscilloscope display of forward loss and reverse loss

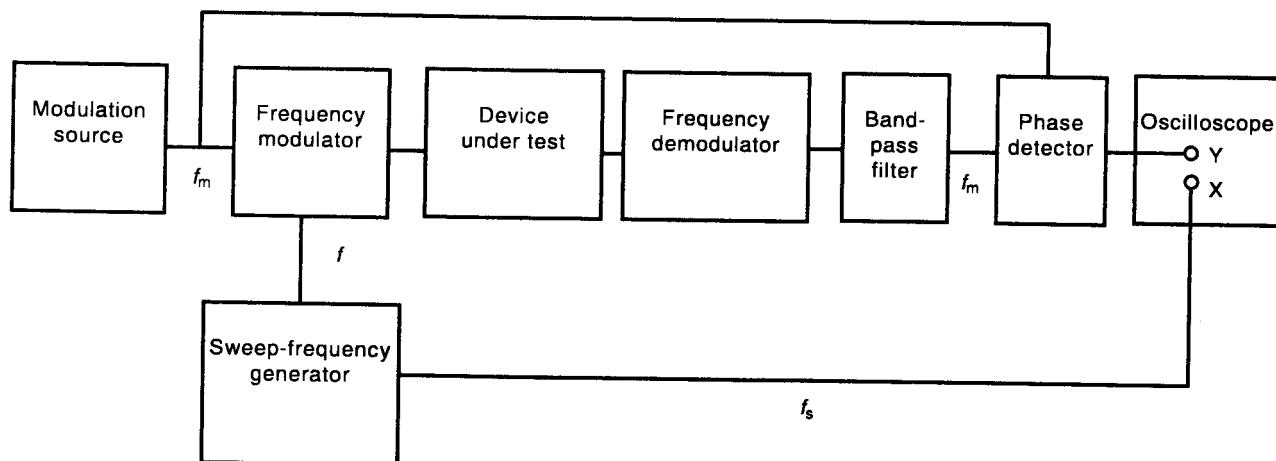
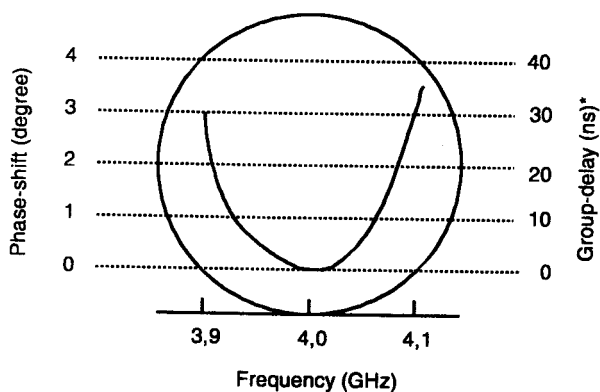


Figure 5 – Arrangement of equipment for measuring phase-shift and group-delay



* In the case of 0,277 778 MHz modulation frequency

Figure 6 – Example of oscilloscope display of phase-shift and group-delay

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc : No. LTD 13 (1916).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams: Manaksanstha
(Common to all offices)

Regional Offices :

	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	{ 323 76 17 323 38 41
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700 054	{ 337 84 99, 337 85 61 337 86 26, 337 91 20
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160 022	{ 60 38 43 60 20 25
Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600 113	{ 254 12 16, 254 14 42 254 25 19, 254 13 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400 093	{ 832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE.
FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR.
LUCKNOW. NAGPUR. NALAGARH. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM.